

Abstract

Laser-induced incandescence (LII) is an optical diagnostic technique that can be used to measure the concentration and primary-particle size distributions of soot with high selectivity. This technique consists of rapid particle heating from the local ambient temperature to close to the soot sublimation temperature (~ 4000 K) by means of a highly energetic laser source, and the immediate recording of the strong thermal radiation as a result of a complex heat and mass transfer balance. The aim of this work is to develop an experimental methodology for measuring the soot concentration in diesel flames by means of laser-induced incandescence.

The development of the methodology consists of two main parts. The first focuses on the calibration of the laser-induced incandescence signal in a laminar diffusion flame under atmospheric conditions, by using the light extinction method as a reference technique. This calibration allows for quantitative values of the concentration of soot. Along with LII measurements, simultaneous laser elastic-scattering measurements (LES) were obtained, which allowed the calculation of the maps of probability, number and relative particle diameter. For this purpose, different algorithms and corrections by digital image processing were developed. This research has also made use of a theoretical model for the LII signal with the intention of developing an adequate interpretation of the images inside the combustion chamber, identify the main limitations of the technique and propose the necessary corrections under different experimental conditions.

The second part is an experimental study of the soot concentration field in a turbulent diesel flame. In this case, an experimental set-up that reproduces the thermodynamic conditions of a diesel engine was used. By strictly following the methodology developed in the first part, along with the adjustments and corrections for high-pressure systems such as compression-ignition engines, a series of parametric studies were carried out in order to characterise the effects of variations in fuel injection pressure, thermodynamic properties of air and nozzle diameter on the soot concentration distribution and its relationship with the flame structure. In this analysis, results from other optical techniques have been used, in order to understand the phenomena that determine the processes of formation and soot oxidation in turbulent flames.